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Euxinia as a dominant process during OAE1a (Early Aptian) on the Eastern Russian Platform and during OAE1b (Early Albian) in the Middle Caspian

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Abstract

© 2016, Science China Press and Springer-Verlag Berlin Heidelberg.A detailed study of the mineral composition and microstructure of the black shales associated with OAE1a (Eastern Russian Platform), OAE1b (Middle Caspian), and the host rocks has been carried out using X-ray diffraction, scanning electron microscopic, and microprobe analyses. The results provide important constraints for depositional environments in the sedimentary basins. Black shales with pyrite framboids imply euxinic (sulfidic) conditions with increased organic matter preservation. Disintegrating framboids suggest partial or complete dissolution of the organic matter inside the framboids due to increasing water oxygenation. OAE1a on the Eastern Russian Platform is heterogeneous as it includes thin interbeds of concretionary coccolith limestones within the interval of bituminous shales, and correlates with the Lower Aptian Rhagodiscus angustus nannofossil zone. The coccolith limestones indicate short intermittent episodes of interrupted stagnation, rapid oxygenation, and restoration of normal marine conditions. The presence of montmorillonite, albite, microcline, and diopside in the bituminous siltstones and in the host siltstones of OAE1a on the Eastern Russian Platform, as well as a high content of titanium in the black siltstones correlated with OAE1b in the Middle Caspian allow proposing significant input of pyroclastic material into the extant sea.

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Keywords

Black shales, Cretaceous, Eastern Russian Platform, Euxinia, Middle Caspian, OAE1a, OAE1b, Oxygenation, Pyrite framboids

References

[1] Arthur M A. 2000. Volcanic contributions to the carbon and sulfur geochemical cycles and global change. In: Sigurdsson H, Houghton B, Mc Nutt S R, Rymer H, Stix J, eds. Encyclopedia of Volcanoes. San Diego: Academic Press. 1045–1056

[2] Baraboshkin E Yu. 2004. Lower Cretaceous ammonite zonal standard of the Boreal Belt (in Russian). Bull MOIP Otd Geol, 79: 44–68

[3] Baraboshkin E Y, Alekseev A S, Kopaevich L F. 2003. Cretaceous palaeogeography of the North-Eastern Peri-Tethys. Paleogeogr Paleoclimatol Paleoecol, 196: 177–208

[4] Baraboshkin E Yu, Mikhailova I A. 2002. New stratigraphic scheme of the lower Aptian in the Volga River middle courses. Stratigr Geol Correl, 10: 603–626

[5] Beerling D J, Lomas M R, Gröcke D R. 2002. On the nature of methane gas-hydrate dissociation during the Toarcian and Aptian Oceanic anoxic events. Am J Sci, 302: 28–49

[6] Bottini C, Erba E, Tiraboschi D, Jenkyns H C, Schouten S, Sinninghe Damsté J S. 2015. Climate variability and ocean fertility during the Aptian stage. Clim Past, 11: 383–402

[7] Bottini C, Mutterlose J. 2012. Integrated stratigraphy of Early Aptian black shales in the Boreal Realm: Calcareous nannofossil and stable isotope evidence for global and regional processes. Newsl Stratigr, 45: 115–137

[8] Bralower T J, Leckie R M, Sliter W V, Thierstein H R. 1995. An integrated Cretaceous microfossil biostratigraphy. Sepm Spec Publ, 54: 65–79

[9] Bushnev D A. 2005. Early Cretaceous anoxic basin of the Russian Plate: Organic geochemistry. Lithol Miner Resour, 40: 21–29

[10] Cavalazzi B, Agangi A, Barbieri R, Franchi F, Gasparotto G. 2014. The formation of low-temperature sedimentary pyrite and its relationship with biologically-induced processes. Geol Ore Deposits, 56: 395–408

[11] Erba E. 2004. Calcareous nannofossils and Mesozoic oceanic anoxic events. Mar Micropaleontol, 52: 85–106

[12] Erba E, Duncan R A, Bottini C, Tiraboschi D, Weissert H, Jenkyns H C, Malinverno A. 2015. Environmental consequences of Ontong Java Plateau and Kerguelen Plateau volcanism. In: Neal C R, Sager W W, Sano T, Erba E, eds. The Origin, Evolution, and Environmental Impact of Oceanic Large Igneous Provinces. Geol Soc Am Spec Paper, 511: 271–303

[13] Farina M, Esquivel D M S, de Barros H G P L. 1990. Magnetic iron-sulphur crystals from a magnetotactic microorganism. Nature, 343: 256–258

[14] Gavrilov Y O, Shchepetova E V, Baraboshkin E Yu, Shcherbinina E A. 2002. The Early Cretaceous anoxic basin of the Russian Plate: Sedimentology and geochemistry. Lithol Mineral Resour, 37: 310–329

[15] Giorgioni M, Keller C E, Weissert H, Hochuli P A, Bernasconi S M. 2015. Black shales-from coolhouse to greenhouse (early Aptian). Cretac Res, 56: 716–731

[16] Grekov I I, Prutsky N I, Enna N L. 2004. The main Phanerizoic and magmatic activity zones (Seat zones) of the North Caucasus (in Russian). Lithosphera, 3: 127–136

[17] Guzhikov A Yu, Baraboshkin E Yu. 2006. Assessment of diachronism of biostratigraphic boundaries by magnetochronological calibration of zonal scales for the Lower Cretaceous of the Tethyan and Boreal Belts. Dokl Earth Sci, 409: 843–846

[18] Guzhikov A Yu, Biribina A V, Baraboshkin E Yu. 2003. New paleomagnetic data for the Hauterivian-Aptian rocks of the Middle Volga region: Global correlation and dating of stratigraphic boundaries. Russ J Earth Sci, 5: 401–430

[19] Hu X, Zhao K, Yilmaz I O, Li Y. 2012. Stratigraphic transition and palaeoenvironmental changes from the Aptian oceanic anoxic event 1a (OAE1a) to the oceanic red bed 1 (ORB1) in the Yenicesihlar section, central Turkey. Cretac Res, 38: 40–51

[20] Jahren A H, Arens N C, Sarmiento G, Guerrero J, Amundson R. 2001. Terrestrial record of methane hydrate dissociation in the Early Cretaceous. Geology, 29: 159–162

[21] Karakitsios A, Kafousia N, Tsikos H. 2010. A review of oceanic anoxic events as recorded in the Mesozoic sedimentary record of mainland Greece. Hell J Geosci, 45: 123–131

[22] Keller C E, Hochuli P A, Weissert H, Bernasconi S M, Giorgioni M, Garcia T I. 2011. A volcanically induced climate warming and floral change preceded the onset of OAE1a (Early Cretaceous). Paleogeogr Paleoclimatol Paleoecol, 305: 43–49

[23] Kenig F, Hudson J D, Sinninghe Damsté J S, Popp B N. 2004. Intermittent euxinia: Reconciliation of a Jurassic black shale with its biofacies. Geology, 32: 421

[24] King C. 2004. The Black Sea: A History. New York: Oxford University Press. 276

[25] Khaidarov I D, Zakirov M R. 2014. Biostratigraphy of the Lower Cretaceous deposits of the Middle Caspian Basin (in Russian). In: Dmitriev A Yu, ed. Problems of Geology and Subsurface Development: Proceedings of the 18th International Scientific Symposium of students, Postgraduates and young Scientists. Part I. Tomsk: Tomsk Polytechnic University Publishing House. 92–94

[26] Larson R L, Erba E. 1999. Onset of the Mid-Cretaceous greenhouse in the Barremian-Aptian: Igneous events and the biological, sedimentary, and geochemical responses. Paleoceanography, 14: 663–678

[27] Li J, Hu X, Zhao K, Cai Y, Sun T. 2016. Paleoceanographic evolution and chronostratigraphy of the Aptian Oceanic Anoxic Event 1a (OAE1a) to oceanic red bed 1 (ORB1) in the Gorgo a Cerbara section (central Italy). Cretac Res, 66: 115–128

[28] Lorenzen J, Kuhnt W, Holbourn A, Flögel S, Moullade M, Tronchetti G. 2013. A new sediment core from the Bedoulian (Lower Aptian) stratotype at Roquefort-La Bédoule, SE France. Cretacs Res, 39: 6–16

[29] Love L G. 1971. Early diagenetic polyframboidal pyrite, primary and redeposited, from the Wenlockian Denbigh Grit Group, Conway, North- Wales, U.K. J Sediment Petrol, 41: 1038–1044

[30] Maurer F, van Buchem F S P, Eberli G P, Pierson B J, Raven M J, Larsen P H, Al-Husseini M I, Vincent B. 2013. Late Aptian long-lived glacio-eustatic lowstand recorded on the Arabian Plate. Terra Nova, 25: 87–94

[31] Menegatti A P, Weissert H, Brown R S, Tyson R V, Farrimond P, Strasser A, Caron M. 1998. High-resolution d13C stratigraphy through the Early Aptian “Livello selli” of the Alpine tethys. Paleoceanography, 13: 530–545

[32] Meyer K M, Kump L R. 2008. Oceanic euxinia in earth history: Causes and consequences. Annu Rev Earth Planet Sci, 36: 251–288

[33] Millán M I, Weissert H J, Fernández-Mendiola P A, García-Mondéjar J. 2009. Impact of Early Aptian carbon cycle perturbations on evolution of a marine shelf system in the Basque-Cantabrian Basin (Aralar, N Spain). Earth Planet Sci Lett, 287: 392–401

[34] Millán M I, Weissert H J, López-Horgue M A. 2014. Expression of the late Aptian cold snaps and the OAE1b in a highly subsiding carbonate platform (Aralar, northern Spain). Paleogeogr Paleoclimatol Paleoecol, 411: 167–179

[35] Moullade M, Tronchetti G, Granier B, Bornemann A, Kuhnt W, Lorenzen J. 2015. High-resolution integrated stratigraphy of the OAE1a and enclosing strata from core drillings in the Bedoulian stratotype (Roquefort-La Bédoule, SE France). Cretac Res, 56: 119–140

[36] Nikishin A M, Khotylev A O, Bychkov A Y, Kopaevich L F, Petrov E I, Yapaskurt V O. 2013. Cretaceous volcanic belts and the evolution of the Black Sea Basin. Moscow Univ Geol Bull, 68: 141–154

[37] Oschmann W. 2011. Black shales. In: Reitner J, Thiel V, eds. Encyclopedia of Geobiology. Dordrecht: Springer Science+Business Media B.V. 201–210

[38] Pancost R D, Crawford N, Magness S, Turner A, Jenkyns H C, Maxwell J R. 2004. Further evidence for the development of photic-zone euxinic conditions during Mesozoic oceanic anoxic events. J Geol Soc, 161: 353–364

[39] Park M H, Kim I S, Ryu B J. 2003. Framboidal pyrites in Late Quaternary core sediments of the East Sea and their paleoenvironmental implications. Geosci J, 7: 209–215

[40] Raiswell R, Berner R A. 1985. Pyrite formation in euxinic and semi-euxinic sediments. Am J Sci, 285: 710–724

[41] Roth P H. 1978. Cretaceous nannoplankton biostratigraphy and oceanography of the northwestern Atlantic Ocean. Initial Reports of the Deep Sea Drilling Project, 44: 731–759

[42] Sames B, Wagreich M, Wendler J E, Haq B U, Conrad C P, Melinte-Dobrinescu M C, Hu X, Wendler I, Wolfgring E, Yilmaz I Ö, Zorina S O. 2016. Review: Short-term sea-level changes in a greenhouse world—A view from the Cretaceous. Paleogeogr Paleoclimatol Paleoecol, 441: 393–411

[43] Sanchez-Hernandez Y, Maurrasse F J M R. 2014. Geochemical characterization and redox signals from the latest Barremian to the earliest Aptian in a restricted marine basin: El Pui section, Organyà Basin, south-central Pyrenees. Chem Geol, 372: 12–31

[44] Sawlowicz Z. 1993. Pyrite framboids and their development: A new conceptual mechanism. Geol Rundsch, 82: 148–156

[45] Scotese C R. 2014. Atlas of Early Cretaceous Paleogeographic Maps. PALEOMAP Atlas for ArcGIS, Vol.2. The Cretaceous. Maps 23–31. Mollweide Projection. PALEOMAP Project. Evanston. IL

[46] Schlanger S O, Jenkyns H C. 1976. Cretaceous oceanic anoxic events: Causes and consequences. Geologie en Mijnbouw, 55: 179–184

[47] Sinton C W, Duncan R A. 1997. Potential links between ocean plateau volcanism and global ocean anoxia at the Cenomanian-Turonian boundary. Econ Geol, 92: 836–842

[48] Taylor G R. 1983. A mechanism for framboid formation I The role of bacteria. A reply to Dr. S. I. Kalogeropoulos and a further contribution. Mineral Deposita, 18: 129–130

[49] Tejada M L G, Suzuki K, Kuroda J, Coccioni R, Mahoney J J, Ohkouchi N, Sakamoto T, Tatsumi Y. 2009. Ontong Java Plateau eruption as a trigger for the early Aptian oceanic anoxic event. Geology, 37: 855–858

[50] Tiraboschi D, Erba E, Jenkyns H C. 2009. Origin of rhythmic Albian black shales (Piobbico core, central Italy): Calcareous nannofossil quantitative and statistical analyses and paleoceanographic reconstructions. Paleoceanography, 24: PA2222

[51] van Breugel Y, Schouten S, Tsikos H, Erba E, Price G D, Sinninghe Damsté J S. 2007. Synchronous negative carbon isotope shifts in marine and terrestrial biomarkers at the onset of the early Aptian oceanic anoxic event 1a: Evidence for the release of 13C-depleted carbon into the atmosphere. Paleoceanography, 22: PA1210

[52] Wang L, Shi X, Jiang G. 2012. Pyrite morphology and redox fluctuations recorded in the Ediacaran Doushantuo Formation. Paleogeogr Paleoclimatol Paleoecol, 333-334: 218–227

[53] Ulmishek G F. 2001. Petroleum Geology and Resources of the North Caspian Basin, Kazakhstan and Russia. U.S. Geological Survey Bulletin, 2201-B

[54] Weissert H, Erba E. 2004. Volcanism, CO and paleoclimate: A Late Jurassic-Early Cretaceous carbon and oxygen isotope record. J Geol Soc London, 161: 695–702

[55] Wignall P B, Newton R, Brookfield M E. 2005. Pyrite framboid evidence for oxygen-poor deposition during the Permian–Triassic crisis in Kashmir. Paleogeogr Paleoclimatol Paleoecol, 216: 183–188

[56] Zakharov Y D, Baraboshkin E Yu, Weissert H, Michailova I A, Smyshlyaeva O P, Safronov P P. 2013. Late Barremian-early Aptian climate of the northern middle latitudes: Stable isotope evidence from bivalve and cephalopod molluscs of the Russian Platform. Cretac Res, 44: 183–201

[57] Zorina S O. 2014. Eustatic, tectonic, and climatic signatures in the Lower Cretaceous siliciclastic succession on the Eastern Russian Platform. Paleogeogr Paleoclimatol Paleoecol, 412: 91–98

[58] Zorina S O. 2016. Sea-level and climatic controls on Aptian depositional environments of the Eastern Russian Platform. Paleogeogr Paleoclimatol Paleoecol, 441: 599–609

[59] Zorina S O. 2009. Sequence stratigraphy of Lower Cretaceous deposit on the eastern Russian Plate. Rus Geol Geophys, 50: 430–437